Generative AI-Empowered Simulation for Autonomous Driving in Vehicular Mixed Reality Metaverses

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Abstract

In the vehicular mixed reality (MR) Metaverse, the discrepancy between physical and virtual entities can be overcome by fusing the physical and virtual environments with multi-dimensional communications in autonomous driving systems. Assisted by digital twin (DT) technologies, connected autonomous vehicles (AVs), roadside units (RSUs), and virtual simulators can maintain the vehicular MR Metaverse via simulations for sharing data and making driving decisions collaboratively. However, it is challenging and costly to enable large-scale traffic and driving simulation via realistic data collection and fusion from the physical world for online prediction and offline training in autonomous driving systems. In this paper, we propose an autonomous driving architecture, where generative AI is leveraged to synthesize unlimited conditioned traffic and driving data via simulations for improving driving safety and traffic control efficiency. First, we propose a multi-task DT offloading model for the reliable execution of heterogeneous DT tasks with different requirements at RSUs. Then, based on the preferences of AV's DTs and real-world data, virtual simulators can synthesize unlimited conditioned driving and traffic datasets for improved robustness. Finally, we propose a multi-task enhanced auction-based mechanism to provide fine-grained incentives for RSUs on providing resources for autonomous driving. The property analysis and experimental results demonstrate that the proposed mechanism and architecture are strategy-proof and effective.